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Hyponatremia in children with lower respiratory tract infection: a cross-sectional study

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ABSTRACT

Introduction: Lower respiratory tract infections (LRTIs) are leading cause of pediatric mortality in Nepal. Hyponatremia is common electrolyte imbalance in severe infections, but its prevalence and impact in high-altitude, resource-limited settings like Jumla are poorly characterized. This study aimed to determine prevalence and clinical significance of hyponatremia in children hospitalized with LRTIs.

Methods: Hospital-based cross-sectional study was conducted from January 2024 to June 2025, including 80 children aged 1 month to 12 years with LRTIs. Serum sodium levels were measured, and hyponatremia was classified as mild (130-134 mEq/L), moderate (125-129 mEq/L), or severe (<125 mEq/L). Associations with clinical parameters and outcomes were analyzed.

Results: Prevalence of hyponatremia was 56.3%, predominantly mild (77.8% of hyponatremic cases). Hyponatremia was significantly associated with clinical signs of severe respiratory distress, including chest indrawing (p=0.001), crackles (p<0.001), and nasal flaring (p=0.004). Children with hyponatremia had markedly higher needs for continuous positive airway pressure (CPAP) (48.9% vs. 2.9%, p<0.001) and ventilator support (22.2% vs. 5.7%, p=0.010). A longer hospital stay was strongly correlated with lower sodium levels ($r = -0.43$, $p < 0.001$). Furthermore, significant negative correlations were observed between serum sodium and both absolute neutrophil count ($r = -0.57$, $p < 0.001$) and white blood cell count ($r = -0.42$, $p = 0.0001$).

Conclusion: Hyponatremia is highly prevalent among children with LRTIs in Jumla and is associated with increased disease severity, including respiratory support needs and prolonged hospitalization. Routine sodium screening can aid in risk stratification and guide fluid management in this vulnerable high-altitude population.

Keywords: Children, High altitude, Hyponatremia, Lower respiratory tract infection, Nepal, Respiratory support

INTRODUCTION

Lower respiratory tract infections (LRTIs) encompass pneumonia, bronchiolitis, and bronchopneumonia, which account for 1 million deaths annually in children under 5 years of age, nearly 15% of all childhood mortality worldwide.[1] The burden is disproportionately higher in low- and middle-income countries (LMICs), where 99% of these deaths occur, with South Asia contributing approximately 35% of the global pneumonia mortality.[2] In Nepal, LRTIs are responsible for about 30% of under-5 mortality.[3] This burden is worsened by factors such as malnutrition, poor sanitation, indoor air pollution, low immunization coverage, and limited access to quality healthcare in remote areas like Karnali province.[4]

Jumla district, situated at an altitude exceeding 2,500 meters above sea level, represents one of the country's most underserved healthcare environments.[5] The high altitude induces physiological adaptations that may influence the clinical presentation and progression of respiratory illnesses in children.[6] Furthermore, the combination of cold exposure and hypoxia increases metabolic oxygen demands while compromising oxygen delivery, potentially worsening respiratory distress.[7]

Hyponatremia represents the most frequently encountered electrolyte disturbance in hospitalized children, particularly those with acute infectious diseases.[8] The predominant pathophysiological mechanism is the syndrome of inappropriate antidiuretic hormone secretion (SIADH), leading to impaired free water excretion and dilutional hyponatremia.[9] Hyponatremia has been consistently associated with increased disease severity, prolonged hospitalization, greater requirement for intensive care support, and elevated mortality rates.[10,11]

Epidemiological studies have documented hyponatremia prevalence ranging from 20% to 50% among children with LRTIs.[12] In Nepal, research at Tribhuvan University Teaching Hospital identified hyponatremia in 47.5% of children with severe pneumonia, with moderate-to-severe cases predicting adverse outcomes.[13] Chronic hypoxia at high altitude may enhance antidiuretic hormone (ADH) secretion, while increased insensible losses could independently affect sodium homeostasis.[14]

Therefore, this study aims to fill this critical knowledge gap by evaluating the prevalence and clinical impact of hyponatremia in this specific high-altitude context.

METHODS

This was a hospital-based, cross-sectional study conducted at the Pediatric Department of Karnali Academy of Health Sciences (KAHS) Teaching Hospital, Jumla, Nepal, from January 2024 to June 2025. The hospital serves as a tertiary referral center for the Karnali province, catering to a predominantly rural, high-altitude population.

Children aged 1 month to 12 years admitted with LRTIs, diagnosed according to World Health Organization (WHO) criteria (cough <2

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weeks, fast breathing, chest indrawing, or refusal to feed), were included. Children with chronic illnesses (e.g., congenital heart disease, renal disorders), dehydration, or those who had received prior electrolyte therapy were excluded.

The total of 80 participants were included in the study. Consecutive sampling was employed to minimize selection bias and ensure a representative sample of all eligible children admitted during the study period, thereby enhancing the generalizability of our findings within this specific hospital setting. All recruited participants had complete data for serum sodium and the primary outcome variables; no cases were excluded due to missing data.

Data collection used a structured proforma covering socio-demographics, vital signs, clinical presentations, biochemical values [serum sodium, white blood count (WBC), absolute neutrophil count (ANC), and outcomes [duration of hospital stay, continuous positive airway pressure (CPAP)/ventilator need, mortality]. Serum sodium was measured via ion-selective electrode; hyponatremia was graded as mild (130-134 mEq/L), moderate (125-129 mEq/L), severe (<125 mEq/L).WBC abnormal (>11x10^9/L or <4x10^9/L), and ANC abnormal (>7.5x10^6/L or <1.5x10^6/L).

Data were analyzed using SPSS version 26. Descriptive statistics included means ± SD and frequencies. Associations were tested with chi-square/ Fisher's exact tests for categorical variables, and Pearson correlation was used to find the correlation between serum sodium and determinants like WBC count, ANC count and duration of hospital stay. P<0.05 was significant.

Ethical clearance was from the Institutional Review Committee (IRC) KAHS (IRC No. 078/079/11). Written informed consent was obtained from guardians in Nepali/English, ensuring confidentiality and voluntary participation. No interventions were involved beyond standard care.

RESULTS

Total patient included on the study were 80 study participants. The cohort was predominantly male i.e. 50(62.5%) and consisted mostly of infants i.e. 40(50.0%). Hyponatremia was a common finding, present in 45 patients (56.3%), while the remaining 35 (43.8%) had normal sodium levels. Among those with hyponatremia, the condition was classified as mild in 35(43.8%) of the total population and moderate in 10(12.5%) with no cases of severe hyponatremia recorded (Table 1).

Table 1: Descriptive Characteristics of the Study Population(n=80)

Category	Frequency (n)	Percentage (%)
Gender		
Male	50	62.5
Female	30	37.5
Age Group		
Infants	40	50.0
Toddlers	20	25.0
Preschool	3	3.8
>6 years	17	21.3
Hyponatremia Status		
Hyponatremia	45	56.3
Normal Sodium	35	43.8
Severity of Hyponatremia		
Mild	35	43.8
Moderate	10	12.5
Severe	0	0.0

The analysis revealed that several signs of respiratory distress and critical support requirements were significantly more frequent in the hyponatremia group. Specifically, these patients had a higher prevalence of chest indrawing (66.7% vs. 28.6%, p=0.001), crackles (93.3% vs. 57.1%, p<0.001), and nasal flaring (44.4% vs. 14.3%, p=0.004). Furthermore, the need for advanced respiratory support was markedly greater in the hyponatremia group, with 48.9% requiring CPAP (p<0.001) and 22.2% requiring ventilator support (p=0.010) (Table 2).

Table 2: Association Between Clinical Parameters and Hyponatremia Status (Chi-Square Test)(n=80)

Category	Hyponatremia (n=45) n(%)	Normal Sodium (n=35) n(%)	χ^2 Value	P value
Chest Indrawing				
Yes	30 (66.7%)	10 (28.6%)	11.25	0.001
No	15 (33.3%)	25 (71.4%)		
Refusal to Feed				
Yes	40 (88.9%)	30 (85.7%)	1.07	0.301
No	5 (11.1%)	5 (14.3%)		
Crackles				
Yes	42 (93.3%)	20 (57.1%)	25.93	<0.001
No	3 (6.7%)	15 (42.9%)		
Wheeze				
Yes	10 (22.2%)	15 (42.9%)	3.94	0.047
No	35 (77.8%)	20 (57.1%)		
Nasal Flaring				
Yes	20 (44.4%)	5 (14.3%)	8.10	0.004
No	25 (55.6%)	30 (85.7%)		
CPAP Requirement				
Required	22 (48.9%)	1 (2.9%)	22.18	<0.001
Not Required	23 (51.1%)	34 (97.1%)		
Ventilator Support				
Required	10 (22.2%)	2 (5.7%)	6.65	0.010
Not Required	35 (77.8%)	33 (94.3%)		
Mortality				
Died	3 (6.7%)	0 (0.0%)	2.60	0.107
Improved	42 (93.3%)	35 (100.0%)		

A significant negative correlation was observed, indicating that as inflammatory markers and duration of hospital stay increased, serum sodium levels decreased. This inverse relationship was strongest with the ANC ($r = -0.57$, $p < 0.001$), followed by the duration of hospital stay ($r = -0.43$, $p < 0.001$) and the WBC count ($r = -0.42$, $p = 0.0001$) (Table 3).

Table 3: Correlation of Various Determinants with Serum Sodium Levels

Determinant	Correlation Coefficient (r)	P-value
WBC Count and Sodium	-0.42	0.0001
ANC Count and Sodium	-0.57	<0.001
Duration of Hospital Stay and sodium	-0.43	<0.001

DISCUSSION

This cross-sectional study from Karnali Academy of Health Sciences, Jumla, Nepal, reveals a substantial prevalence of hyponatremia (56.3%) among children hospitalized with lower respiratory tract infections, comparable to findings from other Nepalese institutions.[15] A study conducted at Tribhuvan University Teaching Hospital reported a hyponatremia prevalence of 47.5% in children with severe

pneumonia,[16] while another study from Kathmandu documented rates of 45.2% in pediatric respiratory infections.[17] The higher prevalence observed in our study may reflect the unique environmental challenges of high-altitude settings, where chronic hypoxia and increased metabolic demands could predispose children to SIADH.[18]

The predominance of mild hyponatremia (77.78% of hyponatremic cases) aligns with international literature, where mild-to-moderate electrolyte disturbances are more commonly observed in pediatric respiratory infections than severe derangements.[10] The absence of severe hyponatremia (<125 mEq/L) in our cohort may indicate relatively timely hospital presentation or appropriate fluid management practices at our institution, though delayed care-seeking remains a challenge in rural Karnali.[19]

Our findings demonstrate significant associations between hyponatremia and markers of disease severity. The strong inverse correlation between serum sodium and inflammatory markers particularly ANC ($r=-0.57$, $p < 0.001$) supports the inflammatory hypothesis of hyponatremia in acute infections.[9] Elevated cytokines such as interleukin-6 and tumor necrosis factor-alpha, released during pneumonia, stimulate non-osmotic ADH release, leading to water retention and dilutional hyponatremia.[20] Similarly, the negative correlation with WBC count ($r=-0.42$, $p = 0.0001$) reinforces the relationship between infection severity and electrolyte imbalance, consistent with studies from Indian subcontinent populations.[21] The clinical implications of hyponatremia were evident in respiratory support requirements. Hyponatremic children had nearly five-fold increased odds of requiring CPAP support (OR=4.80, p=0.008) and ventilator assistance (OR=4.71, p=0.083). These findings mirror research from tertiary centers in South Asia, where hyponatremia has been identified as an independent predictor of mechanical ventilation need in pediatric pneumonia.[10] The association with respiratory distress signs, including chest indrawing (p=0.001), crackles (p<0.001), and nasal flaring (p=0.004), suggests intensive monitoring for severe LRTIs in hyponatremic children.[11]

The most striking finding was the significant prolongation of hospital stay in hyponatremic children (10.20±6.77 days versus 5.39±2.32 days, p<0.001), corroborated by the strong negative correlation between sodium levels and length of stay ($r=-0.43$, $p<0.001$). This nearly doubled hospitalization duration has substantial implications for resource-limited settings like Jumla, where bed availability and healthcare costs are critical concerns.[5] Studies from Nepal's tertiary hospitals have similarly documented prolonged admissions associated with electrolyte disturbances, emphasizing the need for early recognition and correction.[22]

Although three deaths occurred exclusively in the hyponatremia group, the association did not reach statistical significance (p=0.107), likely due to small sample size and low overall mortality (3.75%). Larger multicenter studies from Nepal have established hyponatremia as an independent mortality predictor in pediatric sepsis and severe pneumonia,[23] suggesting our trend warrants further investigation with adequate statistical power.

These findings advocate for routine serum sodium screening in children admitted with LRTI in Nepal's high-altitude regions, coupled with judicious fluid management protocols to prevent iatrogenic worsening of hyponatremia while addressing dehydration.[24] A key strength of this study is its focus on a unique, underserved high-altitude pediatric population in Jumla, Nepal, providing novel insights into the burden of hyponatremia in a resource-limited setting with distinct environmental challenges. This study has several limitations. Its single-center, cross-sectional design prevents the establishment of causality. The hospital-based sampling may introduce selection bias, as it only captures children who accessed tertiary care, potentially missing more severe cases in the community or milder cases that did not present. The relatively small sample size limited our power to detect a statistically significant association with mortality. Furthermore, we were unable to quantify potential altitude-related confounders such as the degree of dehydration or cold exposure, which might independently influence sodium homeostasis. Future prospective, multi-center studies including community-based participants are warranted to confirm these findings.

The high prevalence and significant clinical impact of hyponatremia observed in our study call for a change in clinical practice at hospitals in high-altitude regions like Jumla. We recommend that serum sodium measurement be incorporated as a routine, low-cost investigation for every child admitted with an LRTI. An identified hyponatremia should trigger heightened clinical vigilance, anticipating a potentially more severe disease course and a likely need for advanced respiratory support. Furthermore, clinicians should adhere to guidelines recommending isotonic fluids for maintenance in such settings to avoid iatrogenic worsening of hyponatremia, thereby potentially shortening hospital stay and improving resource utilization.[23]

CONCLUSION

In conclusion, this study conducted in the high-altitude region of Jumla, Nepal, establishes hyponatremia as a highly prevalent and significant comorbidity in children hospitalized with LRTIs. The condition was identified in over half of the participants and had significant associations with clinical signs of respiratory distress, a substantially increased need for advanced respiratory support like CPAP and mechanical ventilation, and a notably prolonged hospital stay. The significant inverse correlations with inflammatory markers suggest a pathophysiological link between infection severity and electrolyte imbalance. These findings highlight the critical importance of routine serum sodium screening as part of the initial assessment for pediatric LRTI patients in this unique, resource-limited setting. Implementing this practice can greatly enhance risk stratification, guide appropriate and cautious fluid management, and potentially improve overall patient outcomes.

DECLARATION

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Author contribution

KPT, SS, UG, and MK developed the concept of the research. KPT and MK contributed to the design of the research. KPT, UG, and SS performed the literature search and data collection. Data analysis was conducted by KPT and MK with data interpretation. KPT undertook drafting and reviewing of the manuscript for important intellectual content. KPT, SS, UG, and MK gave final approval of the version ready for submission. All authors agreed to be accountable for all aspects of the work.

Conflict of interest

We have no conflicts of interest to disclose.

Ethical Approval

IRC-KAHS approved this research of Health Sciences with the reference number 078/079/11.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Consent/Assent:

Taken

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